Remarks

Claims 1, 4, 6, 9, 10, 17, 19, 25, 27 and 28 have been amended in response to the Examiner's comments in sections 4-8 of the office action. Basis for the amendments can be found in the specification as a whole. Claims 29 and 30 have been cancelled without prejudice to the filing of divisional applications.

Claim Rejections – 35 U.S.C. .§102

In section 10 of the office action the Examiner rejects claim 10 under 35 U.S.C. §102(a) as being anticipated by Calderbank (US Patent 6,115,427). Reconsideration is requested.

Calderbank describes "a method and apparatus for increasing the data rate and providing antenna diversity using multiple transmit antennas". As described by Calderbank "at the receiver MLSE or other decoding is used to decode the noisy received sequence" (Calderbank, abstract). Calderbank does not disclose the following features of claim 10:

(d) refining the channel estimate for each channel, by processing the received symbols to remove an expected effect of the transmissions carried by all other channels by performing cancellation using relevant parts of the sequence of symbol estimates, and to remove an expected effect of modulation on each symbol, and by averaging the channel estimates over all symbols for each respective channel to produce a refined estimate for each channel;

(e) decoding the information symbols again using the refined channel estimate, to produce a refined sequence of coded symbol estimates, and

(f) repeating steps (d), (e) and (f) until convergence.

Calderbank instead uses pilot sequences, (Calderbank, column 18 lines 23-36) to determine the channel gain and once this channel gain is determined it can be used to decode the information symbols. This method of decoding of Calderbank is shown in Figures 5, 6 and 10, which clearly show a sequential decoding process and

not the iterative process with repeated steps described in this application. Furthermore, this is actually acknowledged by the Examiner in section 18 of the office action.

The Examiner identifies text in columns 11-15 and argues that this shows refining the channel estimate. However, this section of text does not relate to decoding in any way, but is instead criteria for the design of codes (Calderbank, column 10, lines 50-52).

The present invention as defined by the amended claim 10 is clearly distinct from the teaching of Calderbank as described above and it is respectfully submitted that the rejection cannot be sustained.

In section 10 the Examiner also rejects claim 25 under 35 U.S.C. §102(a) as being anticipated by Calderbank. The above arguments in relation to claim 10 are also applicable to claim 25 and the applicants respectfully submit that the rejection of claim 25 cannot be sustained.

Claim Rejections under 35 U.S.C. §103

In section 13 of the office action the Examiner rejects claim 1 under 35 U.S.C. §103(a) as being unpatentable over Calderbank in view of Cimini (US Patent 6,208,669). The Examiner identifies that Calderbank does not show use of a de-multiplexer but argues that Cimini discloses a multiplexer.

Cimini describes a "method and apparatus for mobile data communication" (Cimini, title) in which "multiple carrier tones are used to transmit the data. The carrier tones can be assigned to the respective transmit antennas in such a manner as to provide each antenna with a subset of carrier tones with each subset being spread over the transmission spectrum" (Cimini, abstract). Cimini does not relate to space time coding but to space time diversity (Cimini, first embodiment) and beamforming

(Cimini, modification as described in column 5). Cimini sends different space time symbols simultaneously from different antennas on different tones. This is totally distinct from space time coding where different symbols are sent on the same tone from different antennas simultaneously. In the modification of Cimini, described in column 5, symbols are transmitted from two antennas on the same tone. However, it is the same symbol which is transmitted from these two antennas on the same tone, which results in a beam forming effect. Again, this is totally different from the technology described in Calderbank and in the present application. A skilled person would therefore not combine the teaching of Cimini with that of Calderbank (which relates to space time coding) as they do not relate to the same technology.

In addition the fact that a skilled person would not be motivated to combine Cimini and Calderbank is also highlighted by the different US classifications of the two patents. Calderbank falls within class 375 which relates to pulse or digital communications, whereas Cimini falls within class 370 which relates to multiplex communications. It is noted that in the Examination of Calderbank, nothing from class 370 was searched.

Furthermore, a skilled person would not combine the teaching of Calderbank and Cimini because the use of a de-multiplexer is not compatible with the teaching of Calderbank. Calderbank teaches a direct relationship between the code selection and the number of antennas (Calderbank, column 6 lines 53-55). This is shown clearly in Figure 3 where there are two code sequences for two antennas and also described in the abstract. Use of a demultiplexer would remove this direct relationship and therefore goes against the teaching of Calderbank.

Consequently the present invention as defined by the amended claim 1 is clearly not obvious having regard to this combination of prior art teachings. The applicant respectfully submits that the rejection of claim 1 under 35 U.S.C. §103(a) cannot be sustained.

In sections 13, 16 and 19 of the office action the Examiner also rejects claims 6, 9 and 26 under 35 U.S.C. §103(a) as being unpatentable over Calderbank in view of Cimini. The above arguments in relation to claim 1 are also applicable to claims 6, 9 and 26 and the applicants therefore submit that the rejections cannot be sustained.

In section 18 of the office action the Examiner rejects claim 19 under 35 U.S.C. §103(a) as being unpatentable over Calderbank as applied to claim 10 in view of Brink (US Patent 6,353,911). The above arguments in relation to claim 10 are therefore also applicable. Furthermore, Calderbank does not show the following step of claim 19:

(d) estimate refining means operable to refine the channel estimate for each channel, by processing the received symbols to remove the expected effect of the transmissions carried by all the other channels by performing cancellation using the relevant parts of the sequence of symbol estimates, and to remove the expected effect of modulation on each symbol, and by averaging the channel estimates over all symbols for each respective channel to produce a refined estimate for each channel,

As described above Calderbank uses pilot sequences to determine the channel gain and uses this to decode information symbols. Calderbank does not disclose an "estimate refining means" and does not teach or disclose use of averaging to produce a refined estimate (this application, claim 19). The passage cited by the Examiner in section 18 instead describes a criteria for designing codes as proposed by Calderbank.

Additionally, Calderbank does not disclose "apparatus being arranged to iteratively repeat the refining of the channel estimation" (this application, claim 19) as acknowledged by the Examiner.

Brink does describe a method "for iteratively decoding a multi-level modulated signal" (Brink, abstract), however, Brink does not disclose, teach or suggest iterating "until convergence of the channel estimates occurs" (this application, claim 19). Instead, Brink teaches that "the iterative decoding of a particular transmitted sequence is stopped with an arbitrary termination criterion" (Brink, column 2 lines 4-5). Furthermore, Brink does not show step (d) of the amended claim 19 (shown above). Instead Brink feeds back "soft reliability values" which indicate the reliability of a decision (Brink, column 4 lines 63-67) which is totally distinct from the technique described in claim 19, which describes refining an estimate by the process described in step (d) and iteratively using the new estimate to produce further improved estimates.

As Calderbank and Brink fail to disclose either alone or in combination, step (d) of the amended claim 19 and that the process is iteratively repeated "until convergence of the channel estimation occurs" (this application, claim 19), the applicants respectfully submit that the rejection of claim 19 under 35 U.S.C. §103(a) cannot be sustained.

In section 20 of the office action the Examiner rejects claim 28 under 35 U.S.C. §103(a) as being unpatentable over Calderbank in combination with Cimini and further in view of Brink. The above arguments in relation to claim 19 are also applicable to claim 28 as claim 28 contains the same characterizing features as claim 19.

Cimini does not describe, teach or suggest any of the features missing from Calderbank and Brink because Cimini only makes a passing reference to the decoding operation in Figure 1b and column 2 lines 65-67, and review of the figure clearly shows no iterative process and no "estimate refining means" (this application, claim 28 step (d)). Consequently the present invention as defined by the amended

claim 28 discloses an invention which is clearly not obvious having regard to this combination of prior art teachings. The applicant respectfully submits that the rejection of claim 28 under 35 U.S.C. §103(a) cannot be sustained.

Detailed arguments are not presented in respect of the dependent claims, however the arguments of the Examiner should not be taken to be accepted.

In view of the fact that all of the Examiner's comments have been addressed, further and favorable consideration is respectfully requested.

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Respectfully submitted,

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Constraint length K	Generators in octal	
3	5	7
4	15	17
5	23	35
6	53	75
7	113	171
8	247	371
9	561	753
10	1,167	1,545
11	2,335	3,661
12	4,335	5,723
13	10,533	17,661
14	21,675	27,123

~~Table 1~~**Figure 16**

STC-Algorithm (N_T:N_R)	E_b/N_o dB for 10% FER	Spectral Efficiency (bps/Hz)	E_S/N_o (SNR) dB for 10% FER
Benchmark			
1:1	11.0	1.0	11.0
1:2	4.5	1.0	4.5
1:4	-0.5	1.0	-0.5
STTD (STBC)			
2:1	7.2	1.0	7.2
2:2	2.2	1.0	2.2
STTC-32			
2:1	11.0	2.0	14.0
2:2	4.6	2.0	7.6
MC-STTC-256			
2:1	9.6	2.0	12.6
2:2	3.5	2.0	6.5
4:1	12.0	4.0	18.0
4:2	4.0	4.0	10.0
4:4	-1.5	4.0	4.5
BLAST			
uncoded 2:2	12.0	4.0	18.0
coded 2:2	7.1	2.0	10.1

~~Table 2~~Figure 17

Notes:Notation N_T:N_R is used to denote numbers of antennas at each end of the link.

a) E_S denotes energy per transmitted STS

b) The benchmark is a 1/2-rate k=9 binary convolutional encoder,with output bits mapped to QPSK symbols. In a *static* 1:1 channel it achieves 10% FER for an E_b/N_o of 2.2dB and 1% BER for an E_b/N_o of 1.7dB.

c) The benchmark 1:4 number is approximate, as it has been extrapolated from results at a lower FER

d) 'STTD' is a concatenation of the benchmark encoder with the STTD block code

e) 'STTC-32' is the Tarokh STTC with 32 states, and two information bits per STS

f) 'MC-STTC-256' is a concatenation of the benchmark scheme, a QPSK modulation mapper, and a demux mapper to the different transmit antennas~~, as described in~~. It thus has 2^{k-1}=256 states in the trellis, and a spectral efficiency which depends on the number of transmit antennas.

g) The variants of BLAST shown in the table use 'genie-aided' subtraction of the transmission from the stronger transmit antenna when detecting the transmission from the weaker.

h) The 'uncoded' BLAST case uses no error correction code (it is raw QPSK), hence it achieves a high spectral efficiency of 4 bps/Hz. The 'coded' case uses two separate 'benchmark' encoders, one for each antenna.

STC-Algorithm (N_T:N_R)	Spectral efficiency (bps/Hz)	Demodulator soft-metric (LLR) processing (MFLOPS)	Viterbi MLSE processing (MFLOPS)
Benchmark			
1:1	1	0.9	198.4
1:2	1	2.5	198.4
1:4	1	5.0	198.4
STTD (STBC)			
2:1	1	2.5	198.4
2:2	1	5.0	198.4
STTC-32			
2:1	2	8.7	12.4
2:2	2	17.4	12.4
MC-STTC-256			
2:1	2	8.7	99.2
2:2	2	17.4	99.2
4:1	4	69.4	168.6
4:2	4	138.9	168.6
4:4	4	277.8	168.6
8:8	8	71,198	1276.4
BLAST (coded)			
2:2	2	0.02+2.5+1.2=3.7	198.4
4:4	4	0.7+5.0+3.7=9.4	198.4
8:8	8	24.8+9.9+8.7=43.4	198.4

~~Table 3~~Figure 18